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Symbolic Compliance Along the Supply Chain: Customer Climate Pressure and Supplier Value-Chain Carbon Accountability in Chinese Listed Firms

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Abstract

Environmental supply-chain governance increasingly requires firms to trace climate accountability across buyer–supplier relationships. This study examines whether downstream customer climate pressure is associated with suppliers' green supply-chain management and value-chain carbon accountability among Chinese listed firms. We construct an exposure-weighted customer pressure measure by combining disclosed top-customer relationships with customer climate-accountability signals, and we decompose this measure into disclosure-based and non-disclosure-based components so that symbolic and substantive accountability can be separated. We then link this measure to supplier green supply-chain indicators, value-chain carbon-disclosure components, Scope 3 disclosure, environmental investment, and reported environmental performance indicators, including air emissions, water pollutant discharge, resource consumption, and environmental tax. Using firm-year panel regressions with fixed effects, alternative pressure measures, selection corrections, and extended outcome tests, we find an association between customer climate pressure and supplier value-chain disclosure. The depth of the association is concentrated where customer carbon-disclosure visibility is observed and is not separately identified in the smaller climate-only subsample, while the value-chain interaction association is positive but imprecisely estimated there. The value-chain disclosure associations are robust to a year-stratified randomization-inference placebo test. We do not find evidence that customer pressure is associated with supplier emissions, resource use, environmental investment, or environmental tax in the available matched samples. The pattern is consistent with symbolic compliance in supply-chain carbon accountability: customer disclosure visibility maps into supplier disclosure visibility, while we do not observe parallel movement in substantive environmental outcomes. The central finding is therefore that downstream customer climate pressure is associated with what suppliers disclose rather than with what they emit, shaping supplier disclosure behavior rather than substantive emission reduction. The estimates apply to supplier-year observations with disclosed and mappable listed-customer links, which we treat as the scope condition of the study rather than as an incidental data limitation.

Keywords: environmental supply chain; green supply-chain management; customer climate pressure; value-chain carbon accountability; Scope 3 disclosure; sustainable operations; symbolic compliance; decoupling

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1. Introduction

Climate accountability is increasingly part of supply-chain governance. Under the GHG Protocol Corporate Value Chain Standard, firms applying Scope 3 accounting identify relevant upstream and downstream emission categories and report value-chain greenhouse-gas emissions [1]. These requirements can alter the information and accountability routines of upstream suppliers, but whether they also change supplier operational and environmental performance remains unclear. This study asks whether suppliers exposed to more climate-accountable customers disclose stronger value-chain carbon accountability and green supply-chain practices.

This question is central to environmental supply-chain governance because it examines how climate-accountability requirements move through buyer–supplier relationships and how suppliers respond through green supply-chain management, value-chain disclosure, Scope 3 reporting, and reported environmental performance indicators. It speaks most directly to SDG 12 on responsible consumption and production and SDG 13 on climate action. It also relates to SDG 9 because value-chain accountability can support industrial upgrading, cleaner production, and resource-use efficiency [2–4]. Prior studies have examined carbon-information disclosure in Chinese listed firms and ESG disclosure in Chinese listed banks [5,6]. This study adds a customer–supplier exposure dimension by asking whether downstream customer climate accountability is reflected in supplier-side value-chain disclosure and green supply-chain practices. It also builds on three streams of supply-chain evidence. Buyers can request climate information from suppliers [7,8]. Customer ESG performance can spill over to supplier ESG performance in China [9]. Scope 3 accounting remains constrained by primary-data sharing, provider divergence, boundary incompleteness, and activity exclusion [10–12]. Economic links also create indirect climate exposure, and climate hazards shape sourcing choices [13,14]. More broadly, firm-level shocks can propagate through production networks when inputs are difficult to substitute [15,16].

China provides a useful empirical setting because the sample period covers several important carbon-market and sustainability-reporting reforms. The sample covers 2014–2024, a period that includes the 2021 launch of China's national carbon market, the 2023 issuance of IFRS S1 [17] and IFRS S2 [18] by the ISSB, the 2024 sustainability reporting guidelines of the Shanghai, Shenzhen, and Beijing stock exchanges, and HKEX's 2024 climate-disclosure reforms that align more closely with IFRS S2 [19–24]. These policy changes strengthen the relevance of value-chain accountability even though complete Scope 3 measurement remains uncommon among Chinese listed firms.

A growing literature shows that environmental and disclosure institutions do more than change reporting formats; they reshape the corporate information environment and, through it, firm behavior and resource allocation. Environmental institutional pressure can raise environmental-disclosure transparency and improve green governance and supply-chain financing [25], while mandatory information-disclosure regimes can lower agency costs and operational risk and change resource-allocation choices such as corporate cash holdings [26]. This logic motivates the link we examine: institutional climate pressure transmitted through customers may first alter the information that suppliers disclose, and only later, if at all, their substantive operations.

We focus on supplier–customer relationships that are observable through disclosed top-customer information. The empirical design therefore focuses on disclosed and traceable supply-chain links. We combine customer exposure weights with customer climate-accountability signals and relate the resulting pressure measure to supplier outcomes covering green supply-chain management, value-chain carbon disclosure, Scope 3 disclosure, environmental investment, and selected real environmental outcomes. Because both customer links and customer climate signals are observed through disclosed informa-

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tion, the measure captures the visible, disclosed slice of customer climate pressure rather than the full, partly unobservable pressure suppliers experience; we therefore distinguish throughout between customer climate pressure as a latent commercial and institutional demand and disclosure visibility as the observable signal we can measure.

Customer climate pressure is associated with supplier value-chain carbon disclosure and value-chain interaction disclosure in the baseline specification. A one-standard-deviation increase in customer pressure is associated with a 0.079 increase in the value-chain disclosure component and a 5.4 percentage-point increase in value-chain interaction disclosure. When customer pressure is limited to climate-only, non-disclosure signals, the disclosure-depth estimate becomes small and imprecise in the smaller observable sample, and the value-chain interaction association is also imprecisely estimated. Customer pressure is also not robustly associated with supplier emissions, resource use, environmental investment, or environmental tax in the available matched samples. The pattern is consistent with symbolic compliance in supply-chain carbon accountability: customer disclosure visibility maps into supplier disclosure visibility, while broader customer climate-accountability signals and real environmental outcomes do not show parallel movement.

The paper contributes to sustainable supply-chain research in three ways. Its central contribution is to separate symbolic from substantive supply-chain climate accountability empirically; the relational pressure measure and its decomposition are the tools that make this separation possible. First, it develops a relational measure of downstream customer climate pressure based on disclosed customer–supplier links, extending the analysis from firm-level ESG attributes to customer–supplier exposure. Unlike existing ESG-spillover models, which regress a supplier’s ESG score on a customer’s ESG score and therefore cannot tell disclosure mimicry apart from substantive transmission, our exposure-weighted index is built from the specific customer links a supplier discloses and can be decomposed into disclosure-based and non-disclosure-based parts. Second, it decomposes customer pressure into disclosure-based and non-disclosure-based components and shows that the value-chain disclosure association is reproduced where customer carbon-disclosure visibility is available, while the climate-only pressure measure does not provide statistically reliable evidence on the disclosure-depth margin. This decomposition identifies a measurement and visibility boundary that previous customer–supplier ESG transmission studies have not made explicit. Third, by linking the disclosure finding to a full set of null results on supplier emissions, resource use, environmental investment, and environmental tax, the paper documents a symbolic-compliance pattern in Chinese supply-chain carbon accountability. Customer disclosure visibility is what travels along the supply chain. This reading connects supply-chain climate research to the institutional isomorphism, legitimacy, and decoupling literature [27–31].

The remainder of this paper is organized as follows. Section 2 develops the literature-based arguments and hypotheses. Section 3 describes the institutional setting, data construction, variable measurement, and empirical specifications. Section 4 reports the main results, robustness checks, selection tests, heterogeneity tests, and extended outcome analyses. Section 5 discusses the theoretical, managerial, and policy implications of the findings. Section 6 concludes the paper and outlines the main evidence boundaries and future research directions.

2. Literature and Hypothesis Development

2.1. Environmental Supply-Chain Pressure

Environmental supply-chain research argues that sustainability expectations can move upstream when powerful customers require suppliers to meet environmental standards, provide carbon information, or participate in green procurement systems. Prior buyer–supplier climate research shows that buyers can request climate-risk and emissions-reduction information from suppliers [7,8], and global evidence shows that socially responsible customers can transmit CSR practices to suppliers [32]. Evidence from Chinese listed firms also shows that customer ESG performance affects subsequent supplier ESG performance [9]. Resource-dependence theory argues that organizations respond to external actors that control critical resources [33]. Suppliers that depend on important customers may adjust practices and disclosures to preserve access to critical revenue, legitimacy, and relational resources. Customer pressure can therefore operate through procurement requirements, supplier screening, technical audits, long-term contracting, product compliance, or reputational expectations. In such settings, customers do not need to own suppliers to influence supplier behavior; repeated transactions and dependence can make climate and environmental expectations commercially salient.

The first mechanism is operational. If customers integrate climate and environmental requirements into procurement, suppliers may respond by adopting green supply-chain strategies, creating dedicated management structures, implementing green supplier management, or reporting cleaner production practices. These responses are costly and organizationally specific, so they may not appear uniformly across all firms. Still, if customer climate pressure matters, one would expect at least some positive association with supplier-side green supply-chain management.

Hypothesis 1. *Downstream customer climate pressure is positively associated with supplier green supply-chain management and operational green-practice indicators.*

2.2. Value-Chain Carbon Accountability

Carbon accountability differs from broad environmental disclosure because it connects climate-related actions to value-chain partners, Scope 3 emissions, and upstream or downstream management. Scope 3 research identifies four measurement barriers: limited primary-data sharing, provider divergence, reporting-boundary gaps, and activity exclusion [10–12]. These barriers make complete Scope 3 quantification difficult, especially when firms lack supplier-level emissions data or standardized reporting systems.

Value-chain carbon-accountability disclosure can therefore emerge before complete Scope 3 measurement. Institutional theory explains why firms may adopt disclosure and management routines in response to pressure from regulators, powerful customers, professional standards, and peer practices [28]. Legitimacy theory also suggests that firms use disclosure to respond to external expectations and maintain organizational acceptance [29]. In this context, suppliers can disclose value-chain interaction, upstream and downstream customer management, and carbon-management processes before they can fully quantify or reduce value-chain emissions.

Legitimacy theory explains why firms disclose in response to external expectations [29], and signaling theory explains why value-chain disclosure can signal responsiveness under information asymmetry [34]. Suppliers face multiple audiences, including customers, regulators, investors, local communities, and employees. Value-chain carbon disclosure allows suppliers to show that they recognize how emissions and climate risks are embedded in transactions, products, logistics, procurement, and customer requirements. Customer climate pressure should therefore be clearly reflected in value-chain carbon-accountability disclosures, even when complete Scope 3 reporting remains limited.

A growing body of work shows that mandatory disclosure policies reshape the corporate information environment and, through it, operational and financial decisions, not merely the wording of reports. Environmental institutional pressure can raise environmental-disclosure transparency and improve green governance and supply-chain financing [25], while mandatory information-disclosure regimes can reduce agency costs and operational risk and change resource-allocation choices such as corporate cash holdings [26]. Mandatory CSR and sustainability reporting can also affect capital markets, stakeholders, firm behavior, and real organizational responses [35]. This literature implies that customer-side disclosure pressure may first change the information suppliers produce; whether it also changes what suppliers do is the empirical question we address by separating value-chain disclosure outcomes from reported environmental outcomes.

Two channels can produce this association (Figure 1). The first is substantive transmission: customers with stronger climate ambition, management, and performance push suppliers through procurement requirements, audits, and contracting, and supplier value-chain disclosure tracks this real pressure. The second is disclosure-channel mimicry: customers' own carbon-disclosure routines travel along the supply chain through institutional isomorphism, and suppliers match customer disclosure formats and depth without comparable changes in underlying operations. Institutional decoupling and selective-disclosure research further suggest that organizations may adopt externally legitimate disclosure structures, and disclose the most legible elements of compliance, without corresponding changes in underlying practices, especially when external audiences reward visible conformity more than verified operational change [27,30,31]. The two channels predict different empirical signatures. The first should be visible in supplier real environmental outcomes as well as in disclosure. The second should appear in disclosure-overlapping measures and should not connect to real outcomes. Both channels predict a positive association with supplier disclosure. We therefore distinguish them empirically through a construct-overlap test (Section 4.3) and through extended outcome tests (Section 4.7), without formalizing them as separate hypotheses.

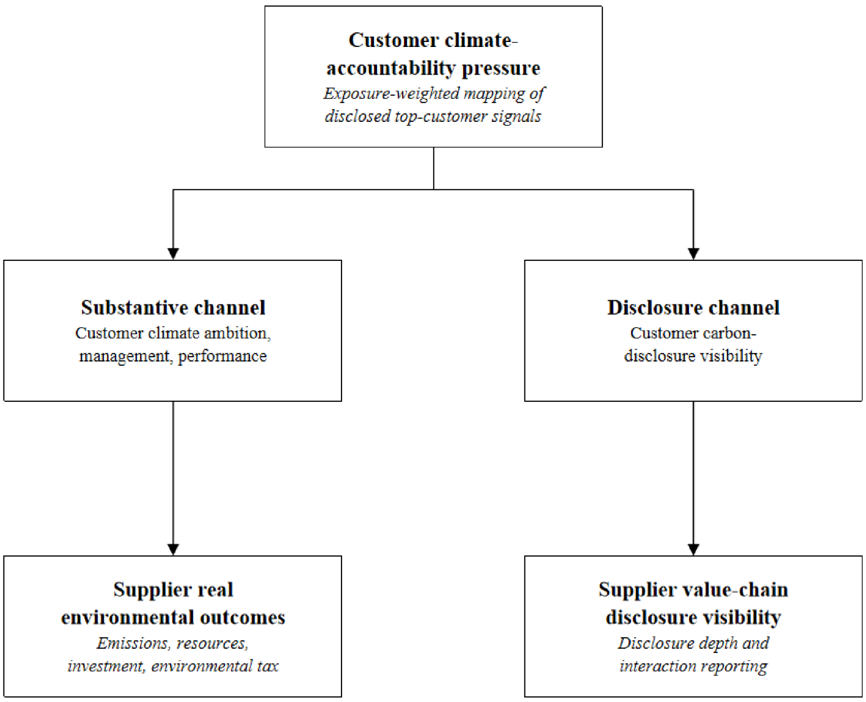

Figure 1. Two transmission channels of customer climate pressure to supplier outcomes. Substantive channel refers to customer climate ambition, management, and performance. Disclosure channel refers to customer carbon-disclosure visibility.

Hypothesis 2. *Downstream customer climate pressure is positively associated with suppliers' value-chain carbon-accountability disclosure.*

2.3. Boundary Conditions

Customer pressure may not affect all suppliers in the same way. Institutional salience is an important boundary condition. In China, carbon-market development and sustainability-reporting reforms have increased expectations for listed firms to demonstrate climate accountability [19–24]. State-owned enterprises may face closer policy and public scrutiny, while heavy-industry firms are more exposed to carbon and environmental regulation. These firms may therefore have stronger incentives to make their value-chain carbon-accountability disclosure visible. Operational change may still take longer in carbon-intensive sectors because production assets, energy systems, and process technologies are difficult to adjust in the short term.

Hypothesis 3. *The positive association between downstream customer climate pressure and supplier value-chain carbon-accountability disclosure is stronger among firms with higher institutional salience.*

3. Materials and Methods

3.1. Institutional Setting and Data Sources

The institutional setting links the empirical design to recent carbon-market and sustainability-reporting reforms in China. China's national carbon market began trading in July 2021 and initially covered the power sector [19]. In 2024, the Shanghai, Shenzhen, and Beijing stock exchanges issued sustainability-reporting guidelines for listed companies [20–22]. Separately, HKEX adopted phased climate-disclosure reforms that align more closely with IFRS S2 [23]. The ISSB issued IFRS S1 and IFRS S2 in 2023, raising global expectations for sustainability- and climate-related financial disclosure across capital markets [24]. These reforms provide the institutional background for examining whether customer climate-accountability signals are reflected in supplier value-chain disclosure during 2014–2024. Appendix A Table A4 reports a pre/post-2021 comparison.

This study uses CSMAR data for Chinese listed firms from 2014 to 2024, covering customer–supplier relationships, supply-chain exposure and concentration, green supply-chain management, carbon disclosure, environmental investment, carbon governance, and firm-level financial controls.

Table 1 reports the source blocks and their empirical role. The supply-chain component is built from disclosed customer and supplier relationships, top-five customer and supplier information, and supply-chain concentration measures. The green supply-chain component uses management indicators and text-frequency measures. The carbon-accountability component uses carbon-disclosure index details, including value-chain interaction, upstream/downstream customer management, and Scope 3 disclosure items. This structure allows the paper to compare operational green supply-chain responses with carbon-accountability responses.

Table 1. Data sources and empirical role.

Data Block	Data Items	Use in Manuscript
Supply-chain exposure	CSMAR top-five customers/suppliers; supplier and customer concentration	Construct customer climate pressure and mapping coverage
Customer climate-accountability signals	Customer-side carbon disclosure, value-chain items, and climate-accountability indicators	Build customer pressure components

Table 1. *Cont.*

Data Block	Data Items	Use in Manuscript
Green supply-chain management	Green supply-chain strategy, organization, production, supplier management, and GSC text frequency	Measure operational response outcomes and channel associations
Value-chain carbon accountability	Carbon-disclosure index (CDI) value-chain disclosure and interaction components; upstream/downstream customer management	Measure primary value-chain accountability outcomes
Scope 3/emissions disclosure	CDI Scope 3 indicators and related disclosure items	Measure secondary carbon-accountability outcomes

3.2. Customer Climate Pressure Construction

For each supplier-year, customer climate pressure is constructed by weighting the climate-accountability signals of mapped listed customers by the supplier's disclosed customer exposure. The composite measure combines customer climate ambition, management, performance, and carbon-disclosure/value-chain information where available. It therefore varies across suppliers and years according to both the importance of mapped customers and the climate-accountability profile of those customers.

The measure is based only on disclosed customer links that can be matched to listed-customer climate-accountability signals. Unmapped customers are not imputed. This construction keeps the measure tied to observable supply-chain relationships. Table 2 reports the resulting coverage and shows that customer-pressure observations are narrower than the supplier-side outcome variables. The empirical interpretation is therefore limited to supplier-year observations with observable and mappable customer links. The main pressure variable used in the regressions is cust_press, a standardized exposure-weighted customer climate pressure index that also appears as cust_press in the Section 3.4 model equations. The alternative pressure measures are cust_press_climate, cust_disc_vc, and cust_disc_idx. Two clarifications are important. First, the measure captures disclosure visibility rather than the full latent pressure suppliers face. It records customer climate pressure only when a customer link is disclosed and a customer climate signal is reported. Undisclosed or unobserved pressure is outside the measure by design. We therefore state when an association may reflect shared disclosure visibility rather than substantive demand. Second, coverage is about five percent of firm-years (Table 2). This coverage is a scope condition of the study rather than an incidental data limitation. The estimates describe suppliers whose downstream climate pressure is observable through disclosed and mappable listed-customer links. These are the relationships through which traceable and commercially salient supply-chain pressure is expected to operate. We do not generalize the estimates to customer–supplier relationships that cannot be observed.

Table 2. Key variable coverage.

Variable	Description	n	coverage_pct
cust_press	Standardized composite customer climate pressure	2265	5.23
cust_press_climate	Customer pressure from climate ambition/management/performance	1103	2.55
cust_disc_vc	Customer value-chain/carbon-disclosure pressure	2254	5.20
cust_cov	Weighted customer mapping coverage	2265	5.23
gsc_supplier	Implemented green supplier management	26,039	60.11

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Table 2. *Cont.*

Variable	Description	n	coverage_pct
gsc_strategy	Green supply-chain management strategy	26,039	60.11
gsc_wordfreq_log	Green supply-chain text frequency, log	24,530	56.63
vc_depth	Carbon-disclosure value-chain component	27,388	63.22
scope3	Any Scope 3 disclosure	27,388	63.22
ep_invest_log	Environmental investment, log	5489	12.67

Note: Customer-pressure coverage is narrower because it requires listed-customer mapping.

3.3. Outcomes

Supplier outcomes include green supply-chain management strategy, green supply-chain management organization, implementation of green supplier management, green production, green product, green information disclosure, green supply-chain word frequency, carbon-disclosure value-chain component scores, value-chain interaction, upstream/downstream customer management, Scope 3 disclosure, and environmental investment. These outcomes separate three layers of response. The first layer is operational green supply-chain management. The second is textual and management disclosure about green supply chains. The third is carbon-accountability disclosure, especially whether the firm discusses value-chain interaction and Scope 3-related information.

3.4. Empirical Specification

Customer climate pressure is constructed from mapped listed customers and their climate-accountability signals. For supplier i in year t, the measure is:

$$\text{cust\_press}_{it} = z\left(\sum\nolimits_{j \in C_{it}^{M}} w_{ijt} \times \text{ClimateSignal}_{jt}\right), \text{ where } w_{ijt} = \frac{s_{ijt}}{\sum_{j \in C_{it}^{M}} s_{ijt}}. \quad (1)$$

C_{it}^{M} denotes the set of mapped listed customers of supplier i in year t. s_{ijt} is the disclosed customer-exposure share between supplier i and customer j. w_{ijt} is the normalized customer-exposure weight. $ClimateSignal_{jt}$ is the climate-accountability signal of customer j in year t. $z(\cdot)$ standardizes the pressure measure. Unmapped customers are not imputed.

The baseline fixed-effects model is:

$$Y_{it} = \alpha + \beta\, cust\_press_{it} + \Gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it}. \quad (2)$$

Y_{it} denotes the supplier outcome for firm i in year t. $cust\_press_{it}$ is the standardized customer climate pressure measure. X_{it} is the vector of firm-level controls. μ_i denotes firm fixed effects, and λ_t denotes year fixed effects. Standard errors are clustered by firm. Binary outcomes are estimated as linear probability models so that coefficients remain comparable across specifications.

The stricter industry-year specification is:

$$Y_{it} = \alpha + \beta\, cust\_press_{it} + \Gamma' X_{it} + \mu_i + \theta_{kt} + \varepsilon_{it}. \quad (3)$$

θ_{kt} denotes industry-year fixed effects for industry k in year t. This specification absorbs industry-specific reporting trends and policy shocks.

Heterogeneity tests use:

$$Y_{it} = \alpha + \beta_1\, cust\_press_{it} + \beta_2\, M_{it} + \beta_3\, cust\_press_{it} \times M_{it} + \Gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it}. \quad (4)$$

M_{it} denotes the moderator. The moderators include state ownership, heavy-industry exposure, customer concentration, supply-chain concentration, overseas exposure, and foreign ownership. The coefficient β_3 captures whether the association between customer climate pressure and supplier outcomes differs across the moderator.

Lead-lag tests use:

$$Y_{it} = \alpha + \beta\, cust\_press_{i,t+\updownarrow} + \Gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \updownarrow = \{-1, 0, +1\}. \quad (5)$$

$cust\_press_{i,t+\updownarrow}$ denotes lagged, current, or future customer climate pressure. These tests examine timing for selected outcomes.

The selection correction first estimates the observability of customer pressure:

$$\Pr(Selected_{it} = 1) = \Phi(\delta_0 + \delta_1\, Z_{it} + \delta_2\, X_{it} + \eta_k + \lambda_t). \quad (6)$$

$Selected_{it}$ equals one when customer climate pressure is observable. Z_{it} includes the excluded observability predictors. X_{it} includes firm-level controls. η_k denotes industry fixed effects, and λ_t denotes year fixed effects.

The second-stage robustness model is:

$$Y_{it} = \alpha + \beta\, cust\_press_{it} + \rho\, IMR_{it} + \Gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it}. \quad (7)$$

IMR_{it} is the inverse Mills ratio from the Probit selection model. The IPW tests use stabilized weights for selected observations. The design is observational, so the results are interpreted as fixed-effects associations.

Channel association tests follow the baseline fixed-effects specification and add the relevant channel variable, such as green information disclosure, while retaining customer climate pressure and firm controls.

3.5. Robustness Logic and Identification Boundary

The robustness tests address four issues. First, customer pressure may depend on how customer climate signals are aggregated. The analysis therefore compares the composite pressure measure with customer climate score pressure and customer value-chain disclosure pressure. Second, customer pressure is observed only when disclosed major customers can be mapped to listed-customer climate-accountability signals. The study therefore reports coverage statistics and selection-correction tests. Third, industry-year shocks may confound the association because industries differ in climate regulation, reporting norms, export exposure, and customer requirements. The strict specifications add industry-year fixed effects to absorb industry-specific reporting trends and policy shocks. Fourth, reverse timing remains possible in observational panel data. Lead-lag and future-pressure tests examine timing for selected outcomes, while placebo outcomes test whether the pressure measure proxies for broad financial conditions.

Measurement validity also affects the design. ESG ratings differ across providers because agencies use different data, criteria, and aggregation methods [36,37]. Future-emissions measures depend on emissions forecasts, discount rates, and social-cost assumptions [38]. Scope 3 category relevance differs by sector and is difficult to benchmark uniformly [39]. Carbon-reporting quality can be evaluated through multiple dimensions, including transparency, completeness, methodological clarity, boundary coverage, and uncertainty treatment, as illustrated by the Carbon Integrity Index [40]. CDP scores may be useful for external validation only where access, licensing, and firm matching are available [41]. The empirical design therefore compares value-chain accountability, Scope 3 disclosure, and reported environmental outcomes separately. Appendix A Table A1 reports the IPW weight statistics, and Appendix A Table A2 reports variable definitions and extended-data coverage.

3.6. Design of Extended Outcome and Visibility Tests

The extended tests examine whether the value-chain accountability pattern also appears beyond disclosure outcomes. ENV_EmissionDetail, ENV_ResConsDetail, CNE_CEmissY, and CNE_CEmissReduceY provide firm-year measures of selected emissions, resource consumption, greenhouse-gas emissions, and emissions reductions. We group these reported indicators by environmental medium: air emissions comprise sulfur dioxide (SO_2), nitrogen oxides (NO_x), and greenhouse-gas (GHG) emissions; water pollutant discharge comprises chemical oxygen demand (COD), a standard measure of the oxygen-consuming pollutant load in wastewater rather than an airborne emission, and total wastewater discharge; and resource use comprises electricity, water, and coal consumption. Accordingly, we use the term "COD discharge" throughout and reserve "emissions" for releases to air. The COD variable is the reported annual COD discharge amount in CSMAR (ENV_EmissionDetail), a mass quantity (pollutant load) not a concentration, entered as the natural log of one plus the reported amount. OFDI_OPERATEINCOME identifies overseas-revenue exposure, allowing a test of whether internationally exposed firms show stronger Scope 3 or value-chain accountability responses. To avoid double-counting prior-period comparatives, overseas revenue is constructed only from consolidated annual current-period records with Area equal to overseas, VestingPeriod equal to one, and a 31 December reporting date. ER_Structure provides the foreign-ownership measure used to test external-visibility heterogeneity. CNE_EnvirProtectTaxY provides the environmental-tax outcome used to test whether customer pressure is associated with measurable environmental cost-bearing.

These extensions cover four additional evidence blocks: reported environmental outcomes, overseas exposure, foreign-ownership external visibility, and environmental tax. Coverage is uneven because these variables are not observed for every firm-year. The real-outcome tests therefore use the matched fixed-effects sample with aligned controls and singleton handling. Appendix A Table A3 reports the strict fixed-effects diagnostic results for the real-outcome tests.

4. Results

4.1. Data Foundation and Coverage

Table 1 reports the data blocks used to measure supply-chain exposure, customer climate pressure, green supply-chain responses, and carbon-accountability outcomes. Table 2 reports key variable coverage. Appendix A Table A2 defines all variables used in the regression tables. The main data boundary is customer mapping: customer pressure can be measured only when disclosed customers can be linked to listed-customer climate-accountability signals.

The coverage pattern has two implications. First, the supplier-side outcomes are reasonably broad: green supply-chain management indicators cover more than half of the firm-year panel, green supply-chain word frequency covers a similar range, and carbon-disclosure components cover a large portion of observations. Second, customer climate pressure is much narrower because it requires both disclosed customer exposure and customer-side climate-accountability information. This is a central empirical boundary: the analysis estimates associations for traceable customer-pressure relationships and does not claim that the same pattern holds for all customer–supplier ties. The main regressions therefore focus on the observable customer-link subset. The paper therefore reports coverage statistics and selection corrections to make this boundary explicit.

The customer-pressure coverage defines the empirical scope. The estimates describe firms for which downstream customer climate pressure can be observed through disclosed and mappable customer links. This scope is appropriate for the research question because

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supply-chain pressure is expected to operate through visible commercial relationships, procurement dependence, and traceable accountability demands.

Sample sizes differ across tables because each outcome and moderator is observed on a different matched subset. Baseline green-supply-chain and carbon-disclosure tests use the mapped-customer sample with available controls, yielding about 1696 and 1679 observations, respectively. Foreign-ownership and overseas-revenue tests are narrower because these variables are observed for different firm subsets. Environmental investment, environmental tax, emissions, and resource-use tests are smaller still because they require both mappable customer pressure and reported real-outcome data. We therefore interpret changes in N as coverage differences by outcome block rather than as alternative definitions of the core customer-pressure sample.

4.2. Baseline Evidence

Table 3 reports the baseline firm and year fixed-effects results. The clearest associations appear for the value-chain disclosure outcomes. Customer climate pressure is positively associated with value-chain interaction disclosure (estimate = 0.054, p = 0.002) and the value-chain disclosure component (estimate = 0.079, p = 0.006). If value-chain interaction is interpreted as a disclosure indicator, the estimate implies a 5.4 percentage-point increase associated with a one-standard-deviation increase in customer climate pressure. These results provide the baseline support for the value-chain carbon-accountability argument.

Table 3. Baseline fixed-effects results.

Spec.	Outcome	Term	Estimate	SE	p	N
Baseline TWFE	gsc_strategy	cust_press	0.037 **	0.018	0.037	1696
Baseline TWFE	green_production	cust_press	0.025 *	0.015	0.089	1696
Baseline TWFE	scope3	cust_press	−0.009 *	0.005	0.087	1679
Baseline TWFE	scope3_score	cust_press	−0.036 **	0.018	0.039	1679
Baseline TWFE	vc_inter	cust_press	0.054 ***	0.017	0.002	1679
Baseline TWFE	vc_depth	cust_press	0.079 ***	0.028	0.006	1679
Baseline TWFE	ep_invest_log	cust_press	0.048	0.106	0.652	294
Baseline TWFE	gsc_wordfreq_log	cust_press	0.023	0.023	0.328	1606

Note: TWFE denotes two-way fixed effects. All specifications include firm and year fixed effects with firm-clustered standard errors. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$. Variable definitions are in Appendix A Table A2.

The operational results are more selective. Customer pressure is positively associated with green supply-chain strategy (estimate = 0.037, p = 0.037) and green production (estimate = 0.025, p = 0.089). However, the associations with environmental investment (estimate = 0.048, p = 0.652) and green supply-chain text frequency (estimate = 0.023, p = 0.328) are not statistically significant. This pattern indicates that customer climate pressure is reflected most consistently in value-chain accountability disclosure, with weaker evidence for operational and investment-related outcomes.

The Scope 3 results show a different pattern. Customer pressure is negatively associated with any Scope 3 disclosure (estimate = −0.009, p = 0.087) and the Scope 3 disclosure score (estimate = −0.036, p = 0.039) in the baseline table. This result is best read as a boundary condition that separates qualitative value-chain accountability from quantified emissions accountability, developed further in Section 4.7: suppliers more readily adopt narrative value-chain language than quantified Scope 3 figures, which require activity data, boundary choices, emission factors, and verification. One possible interpretation is knowing-conservative disclosure: suppliers exposed to climate-accountable customers may be more aware that Scope 3 quantification is data-sensitive [10–12,39] and may therefore be less willing to disclose Scope 3 information without verifiable data. The pattern is also consistent with disclosure-channel mimicry: when customer pressure is felt through customer disclosure routines, suppliers respond on the value-chain interaction margin, which is the easier disclosure layer, and not on the harder Scope 3 quantification layer. The extended Scope 3 boundary test in Section 4.7 shows that Scope 3 disclosure appears mainly among firms that already disclose value-chain interaction, and that customer pressure has no additional significant association with Scope 3 inside that group.

4.3. Alternative Measurement and Stricter Fixed Effects

Table 4 examines whether the value-chain disclosure result depends on the way customer pressure is measured or on broad industry-year reporting trends. First, when customer pressure is measured using customers' own value-chain disclosure pressure, the coefficient of supplier value-chain disclosure remains positive and significant (estimate = 0.113, p = 0.001). This means that suppliers connected to customers with stronger value-chain carbon disclosure also tend to disclose more value-chain accountability information. Second, to address potential construct overlap, the table adds the two core H2 outcomes using cust_press_climate, a climate-only pressure measure that excludes customer carbon-disclosure and value-chain-disclosure inputs. The coefficients remain positive for value-chain interaction disclosure (estimate = 0.041, p = 0.111) and the value-chain disclosure component (estimate = 0.012, p = 0.778), but they are not statistically significant in the smaller climate-only sample (N = 616).

Table 4. Alternative customer-pressure measures and stricter fixed-effects tests.

Spec.	Outcome	Term	Estimate	SE	p	N
Firm + industry-year FE	gsc_supplier	cust_press	−0.024 *	0.014	0.086	1696
Alternative pressure: cust_press_climate	gsc_supplier	cust_press_climate	−0.043	0.027	0.108	897
Alternative pressure: cust_disc_vc	scope3	cust_disc_vc	−0.007 *	0.004	0.054	1668
Alternative pressure: cust_disc_idx	scope3	cust_disc_idx	−0.010	0.007	0.139	1668
Alternative pressure: cust_disc_vc	vc_depth	cust_disc_vc	0.113 ***	0.032	0.001	1668
Climate-only pressure	vc_inter	cust_press_climate	0.041	0.025	0.111	616
Climate-only pressure	vc_depth	cust_press_climate	0.012	0.043	0.778	616
Firm + industry-year FE	vc_depth	cust_press	0.077 ***	0.027	0.005	1679
Alternative pressure: cust_press_climate	gsc_wordfreq_log	cust_press_climate	0.055	0.035	0.111	857
Firm + industry-year FE	gsc_wordfreq_log	cust_press	0.002	0.024	0.942	1606

Note: Includes alternative pressure measures, the climate-only construct-overlap test, and firm plus industry-year FE tests. Firm and year fixed effects are used unless the specification states firm plus industry-year fixed effects. Standard errors are clustered by firm. * and *** denote $p < 0.10$ and $p < 0.01$. Variable definitions are in Appendix A Table A2.

Third, the value-chain disclosure depth result remains positive after adding firm and industry-year fixed effects (estimate = 0.077, p = 0.005). This specification absorbs industry-specific reporting trends and policy shocks in each year. The continued positive coefficient suggests that the value-chain disclosure result is not only a reflection of broad industry reporting patterns. It also contains supplier-year variation linked to disclosed customer climate pressure.

These tests point to a measurement and visibility boundary for the H2 depth result rather than to a clean within-pressure decomposition. In the full mapped-customer sample, the composite measure is positively associated with value-chain disclosure depth (0.079) and value-chain interaction (0.054). When customer pressure is limited to climate-only, non-disclosure signals, the depth coefficient is 0.012 and the interaction coefficient is 0.041. However, a same-sample diagnostic (Appendix A Table A5, Panel B) shows that this contrast should not be read as pure component removal: on the climate-only observable subsample (N = 616), both the composite and climate-only depth estimates are small and imprecise (0.016, p = 0.735; 0.012, p = 0.778), and the interaction estimates are likewise insignificant (0.044, p = 0.116; 0.041, p = 0.111). The depth-margin association is therefore reproduced only in the larger sample where customer carbon-disclosure visibility is available, which is itself consistent with disclosure-channel mimicry: supplier value-chain disclosure tracks the part of customer pressure that is visible through customer carbon disclosure. Because the depth result is not separately identified on the small climate-only sample, we do not rest the symbolic-compliance reading on the magnitude of the depth change. Instead, the symbolic-compliance interpretation rests on three patterns that do not depend on that comparison: customer pressure is robustly associated with value-chain disclosure in the full sample under randomization inference (Section 4.4); no reported environmental outcome survives strict fixed effects with wild cluster bootstrap inference (Section 4.7); and customer pressure adds nothing to Scope 3 disclosure within firms that already disclose value-chain interaction, as discussed in Section 4.7. The remaining rows do not show comparable positive evidence for green supplier management, Scope 3 disclosure, or green supply-chain textual frequency, reinforcing that the stable association is concentrated in value-chain disclosure rather than broader operational or Scope 3 outcomes.

4.4. Timing, Falsification, and Sample-Selection Checks

Table 5 reports timing and placebo tests. The lead-lag estimates provide limited timing evidence for selected outcomes. For implemented green supplier management, lagged customer pressure is negative and statistically insignificant (estimate = −0.033, p = 0.149), while future customer pressure is also statistically insignificant (estimate = 0.014, p = 0.512). For Scope 3 disclosure, the current and future pressure estimates are both statistically insignificant in the timing sample (estimate = −0.015, p = 0.267; estimate = −0.007, p = 0.633). These results support an association-based interpretation rather than an event-study interpretation for the main value-chain disclosure result.

Table 5. Lead-lag and placebo checks.

Spec.	Outcome	Term	Estimate	SE	p	N
Placebo/non-SCM outcome	CashRatio	cust_press	0.034	0.025	0.169	1880
Placebo/non-SCM outcome	CurrentRatio	cust_press	0.009	0.049	0.860	1880
Lead-lag timing check	gsc_supplier	cust_press_l1	−0.033	0.023	0.149	611
Lead-lag timing check	gsc_supplier	cust_press_f1	0.014	0.021	0.512	611
Lead-lag timing check	scope3	cust_press	−0.015	0.013	0.267	513
Lead-lag timing check	scope3	cust_press_f1	−0.007	0.014	0.633	513
Placebo/non-SCM outcome	finance_expense_assets	cust_press	0.000	0.000	0.479	1880
Lead-lag timing check	gsc_wordfreq_log	cust_press_l1	0.044	0.030	0.146	580
Lead-lag timing check	gsc_wordfreq_log	cust_press	0.030	0.050	0.553	580

Note: Lead-lag tests are not treated as causal proof; placebo outcomes are non-supply-chain financial outcomes.

The placebo tests further narrow the interpretation. Customer climate pressure has statistically insignificant associations with selected non-supply-chain financial outcomes, including cash ratio (estimate = 0.034, p = 0.169), current ratio (estimate = 0.009, p = 0.860), and finance expense scaled by assets (estimate = 0.000, p = 0.479). These results suggest that the pressure measure is not simply capturing broad financial conditions. As a sharper falsification of the main result, we also run a year-stratified randomization-inference (placebo) test with 5000 permutations, randomly reassigning customer climate pressure within each year and re-estimating the baseline (Appendix A Table A5, Panel A). The observed associations lie far in the tails of their placebo distributions: for value-chain disclosure the coefficient is 0.079 (t = 2.76; randomization-inference $p = 0.008$), and for value-chain interaction it is 0.054 (t = 3.11; randomization-inference $p = 0.002$), with both placebo distributions centered near zero. This indicates that the value-chain disclosure associations are unlikely to arise from chance reassignment of customer pressure within years. We next describe how the observed customer-pressure sample differs from the full panel before turning to the formal selection model in Section 4.5.

Table 6 reports customer-mapping selection statistics. Mapped observations are more likely to involve state-owned enterprises and more concentrated supply-chain relationships. The SOE share is higher in the covered sample than in the uncovered sample (0.264 vs. 0.178; standardized difference = 0.211). Customer concentration is also higher among covered observations (12.849 vs. 7.501; standardized difference = 0.347), as is supply-chain concentration (41.476 vs. 34.703; standardized difference = 0.377). These differences show that the evidence is most informative for disclosed and mappable customer relationships, especially where major customers are more visible.

Table 6. Customer-mapping selection statistics.

Variable	Covered Mean	Uncovered Mean	Std. Diff.	Covered N	Uncovered N
Size	21.959	22.183	−0.160	1906	25,712
Lev	0.402	0.400	0.013	2260	33,993
ROA_c	0.036	0.037	−0.008	2256	26,718
Growth_c	0.111	0.131	−0.057	1906	25,697
Cash_c	0.189	0.195	−0.043	1906	25,712
SOE_binary	0.264	0.178	0.211	2265	41,055
CustomerConcentrationHHI	12.849	7.501	0.347	2248	14,621
SupplyChainConcentration	41.476	34.703	0.377	2264	25,632
foreign_share	0.634	1.493	−0.132	1427	18,799
overseas_share	29.324	47.356	−0.349	858	14,573
high_overseas	0.324	0.486	−0.335	858	14,573
analysts	6.854	9.202	−0.267	1071	16,615
long_inst_prop	1.704	2.059	−0.116	855	13,641
real_so2_log	3.349	2.748	0.200	121	2057
real_nox_log	3.672	3.250	0.138	148	2559
real_cod_log	2.569	2.905	−0.172	182	3097
real_wastewater_log	8.204	9.367	−0.253	133	2140
real_electricity_log	11.831	11.841	−0.002	209	3260
real_water_log	9.978	10.520	−0.131	194	3202
ghg_log	10.008	10.495	−0.144	128	1914
co2_red_log	9.447	9.130	0.080	89	1310
env_tax_log	9.305	9.701	−0.125	345	4815
env_tax_burden	0.000	0.000	−0.039	345	4812

Note: Standardized differences describe how mapped-customer observations differ from other observations. Extended rows cover international exposure, external visibility, real environmental outcomes, resource use, and environmental-tax variables observed in the enriched panel.

These tests also point to a clear direction for future data collection. Future studies could extend this design by adding private-customer matching, supplier registries, procurement records, or text-based customer identification. These extensions would broaden customer mapping and reduce the selection created by relying only on disclosed listed-customer links.

4.5. Addressing the Customer-Mapping Coverage Concern

Because customer-pressure coverage is only about five percent of the full panel, Table 7 estimates a first-stage customer-mapping selection model. This first stage examines which firm-year observations are more likely to have observable customer-pressure information. The Probit results show that customer mapping is systematic rather than random. Customer concentration is positively associated with being covered (estimate = 0.119, $p < 0.001$), as are supply-chain concentration (estimate = 0.037, $p = 0.042$) and SOE status (estimate = 0.122, $p < 0.001$). The model has moderate classification performance, with an AUC of 0.704. These results confirm that customer-pressure observability is related to firm and supply-chain characteristics.

Table 7. First-stage customer-mapping selection model.

Selection Covariate	Coef.	SE	*p*
Excluded: industry-year peer mapping rate	−0.043 *	0.024	0.069
Excluded: province-year listed-firm density	−0.100 ***	0.014	0.000
Customer concentration HHI	0.119 ***	0.016	0.000
Supply-chain concentration	0.037 **	0.018	0.042
SOE status	0.122 ***	0.014	0.000
Size	−0.111 ***	0.017	0.000
Leverage	0.075 ***	0.018	0.000
ROA	−0.008	0.016	0.632
Growth	−0.044 ***	0.015	0.003
Cash holdings	−0.031 **	0.016	0.044

Note: Probit model includes year and one-digit industry fixed effects. Excluded observability predictors are industry-year peer mapping rate and province-year listed-firm density; continuous covariates are standardized. Model fit: N = 15,744; selected proportion = 0.120; pseudo R^2 = 0.083; AUC = 0.704; Hosmer–Lemeshow $p = 0.050$. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$.

Table 8 reports second-stage robustness checks for the selected customer-pressure sample. The core value-chain accountability results remain positive after selection corrections. For vc_depth, the baseline coefficient is 0.079 ($p = 0.006$), and the coefficient remains similar after adding the inverse Mills ratio (estimate = 0.077, $p = 0.006$) and after adding the inverse Mills ratio with industry-year fixed effects (estimate = 0.076, $p = 0.005$). The IPW estimate is smaller but remains positive and marginally significant (estimate = 0.056, $p = 0.093$). The value-chain interaction result follows a similar pattern: the baseline estimate is 0.054 ($p = 0.002$), and it remains positive under IMR correction (estimate = 0.053, $p = 0.002$), IMR plus industry-year fixed effects (estimate = 0.042, $p = 0.011$), and IPW weighting (estimate = 0.045, $p = 0.019$).

Table 8. Heckman-style and IPW selection robustness.

Spec.	Outcome	Estimate	SE	*p*	N
Baseline selected sample	gsc_strategy	0.037 **	0.018	0.037	1696
Heckman IMR + industry-year FE	gsc_strategy	0.019	0.016	0.239	1681
Heckman IMR correction	gsc_strategy	0.036 **	0.018	0.041	1681
IPW selected sample	gsc_strategy	0.035 *	0.021	0.095	1681
Baseline selected sample	scope3	−0.009 *	0.005	0.087	1679
Heckman IMR + industry-year FE	scope3	−0.006	0.007	0.400	1662
Heckman IMR correction	scope3	−0.009 *	0.005	0.087	1662
IPW selected sample	scope3	−0.009	0.006	0.127	1662
Baseline selected sample	vc_inter	0.054 ***	0.017	0.002	1679
Heckman IMR + industry-year FE	vc_inter	0.042 **	0.017	0.011	1662

Table 8. *Cont.*

Spec.	Outcome	Estimate	SE	*p*	N
Heckman IMR correction	vc_inter	0.053 ***	0.017	0.002	1662
IPW selected sample	vc_inter	0.045 **	0.019	0.019	1662
Baseline selected sample	vc_depth	0.079 ***	0.028	0.006	1679
Heckman IMR + industry-year FE	vc_depth	0.076 ***	0.027	0.005	1662
Heckman IMR correction	vc_depth	0.077 ***	0.028	0.006	1662
IPW selected sample	vc_depth	0.056 *	0.033	0.093	1662

Note: IMR is the inverse Mills ratio from the first-stage Probit. IPW uses stabilized weights for selected observations. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$.

The operational green-supply-chain result is less stable. For gsc_strategy, the baseline coefficient is positive and significant (estimate = 0.037, p = 0.037), but it becomes insignificant under IMR plus industry-year fixed effects (estimate = 0.019, p = 0.239). This contrast supports the interpretation that customer pressure is observed most consistently in value-chain accountability disclosure.

Tables 7 and 8 show that customer mapping is selective, but the main value-chain disclosure results remain positive after observable-selection adjustments. These tests address observable selection through the first-stage Probit, inverse Mills ratio correction, and IPW weighting. They do not remove all possible unobservable selection, so the results are interpreted as robustness evidence for association rather than as causal identification.

4.6. Heterogeneity and Channels

Table 9 reports heterogeneity tests for institutional salience and exploratory relational checks based on customer and supply-chain concentration. Table 10 reports channel associations. The channel tests examine whether green information disclosure is associated with value-chain carbon disclosure while customer pressure remains in the model.

Table 9. Heterogeneity checks.

Spec.	Outcome	Term	Estimate	SE	*p*	N
SOE	gsc_supplier	cust_x_SOE	−0.057 **	0.029	0.048	1696
Heavy industry	gsc_supplier	cust_x_heavy_ind	0.034	0.029	0.234	1696
High supply-chain concentration	scope3	cust_x_high_sc_conc	0.014	0.009	0.127	1678
High customer concentration	scope3	cust_x_high_cust_hhi	0.010	0.008	0.223	1663
SOE	vc_depth	cust_x_SOE	0.098 *	0.052	0.058	1679
Heavy industry	ep_invest_log	cust_x_heavy_ind	−0.618 ***	0.170	0.000	294
High supply-chain concentration	ep_invest_log	cust_x_high_sc_conc	−0.130	0.113	0.255	294

Note: The table reports coefficients on interaction terms. All specifications include the baseline controls and fixed effects used in the corresponding models; standard errors are clustered by firm. Interaction tests are exploratory. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$.

Table 10. Disclosure-channel association with value-chain carbon disclosure.

Spec.	Outcome	Term	Estimate	SE	*p*	N
Channel association	vc_depth	green_infodisc	0.186 ***	0.068	0.007	1500
Channel association	vc_depth	cust_press	0.064 **	0.030	0.036	1500

Note: Rows report coefficients from the same specification with vc_depth as the dependent variable. The model includes customer pressure, green information disclosure, baseline controls, and fixed effects; standard errors are clustered by firm. The results are associational and are not formal causal mediation tests. ** and *** denote $p < 0.05$ and $p < 0.01$.

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The heterogeneity results provide suggestive evidence for a disclosure-oriented institutional-salience pattern. The interaction between customer pressure and SOE status is positive for value-chain carbon-accountability disclosure (estimate = 0.098, $p = 0.058$) and negative for implemented green supplier management (estimate = −0.057, $p = 0.048$). Institutional salience amplifies the customer-pressure association on the disclosure margin, but not on the operational green supplier-management margin. Heavy-industry exposure does not significantly strengthen implemented green supplier management (estimate = 0.034, $p = 0.234$), and its interaction with environmental investment is negative (estimate = −0.618, $p < 0.001$). This does not support a stronger substantive investment response in heavy industries. Customer and supply-chain concentration checks are exploratory; their interactions with Scope 3 disclosure are positive but statistically insignificant (estimate = 0.010, $p = 0.223$; estimate = 0.014, $p = 0.127$). The pattern is consistent with the symbolic-compliance interpretation, although the interaction tests remain exploratory.

Table 10 reports channel associations. Green information disclosure is positively associated with value-chain carbon disclosure (estimate = 0.186, $p = 0.007$), and customer pressure remains positive in the same specification (estimate = 0.064, $p = 0.036$). This pattern suggests that value-chain carbon disclosure is linked to broader green information disclosure while still retaining a separate association with downstream customer pressure. The channel tests are associational and consistent with a disclosure-channel reading. They are not evidence of substantive customer pressure transmission.

4.7. Extended Outcomes and Scope 3 Boundary Results

The extended tests examine whether the value-chain disclosure pattern also appears in reported environmental performance, overseas exposure, foreign-ownership external visibility, and environmental tax. These variables have lower and uneven coverage, so the tests are used to define the evidence boundary and examine heterogeneity around the main value-chain disclosure results.

Table 11 reports checks using reported environmental outcomes, grouped by medium into air emissions (SO_2, NO_x, and GHG), COD discharge and total wastewater discharge, and resource use (electricity, water, and coal). The baseline columns show positive associations for SO_2 emissions and COD discharge (estimate = 0.728 and 0.178, respectively), but the stricter tests do not provide robust support for these associations. Under firm and industry-year fixed effects with wild cluster bootstrap inference [42], none of the eight reported environmental outcomes reaches conventional significance. The non-sparse outcomes also have wild bootstrap p-values above conventional levels, including NO_x emissions ($p = 0.287$), COD discharge ($p = 0.634$), electricity consumption ($p = 0.309$), and water consumption ($p = 0.625$). The results therefore show that reported air emissions, water pollutant discharge, and resource-use outcomes do not mirror the value-chain disclosure pattern.

Table 12 reports overseas exposure and foreign-ownership external-visibility tests. Overseas-revenue exposure does not strengthen the Scope 3 or value-chain results. The interaction between customer pressure and high overseas revenue is insignificant for any Scope 3 disclosure (estimate = 0.006, $p = 0.896$), Scope 3 disclosure score (estimate = 0.053, $p = 0.708$), value-chain interaction disclosure (estimate = 0.004, $p = 0.945$), and value-chain disclosure (estimate = −0.074, $p = 0.510$). By contrast, foreign ownership strengthens the association between customer pressure and value-chain interaction disclosure (estimate = 0.024, $p = 0.026$). This interaction remains positive and marginally significant under the stricter industry-year fixed-effects specification (estimate = 0.019, $p = 0.090$). This result is consistent with external-visibility heterogeneity, as foreign ownership appears to strengthen the visibility of customer climate pressure in value-chain interaction disclosure.

Table 11. Real environmental outcome boundary checks with wild bootstrap inference.

Outcome	Firm + Year FE	Baseline N	Firm + Industry-Year FE	Wild Bootstrap p	Effective N	Clusters
GHG emissions	−0.174 (0.298)	54	sparse FE support	0.500	16	8
CO_2 emissions reduction	4.638 (2.709)	30	sparse FE support	0.500	16	6
SO_2 emissions	0.728 * (0.393)	66	sparse FE support	0.500	7	3
NO_x emissions	0.437 (0.385)	82	−0.305	0.287	25	11
COD discharge	0.178 * (0.099)	113	−0.203	0.634	55	19
Wastewater discharge	−1.345 * (0.775)	57	sparse FE support	0.500	24	10
Electricity consumption	−0.655 (0.496)	125	−1.649	0.309	69	27
Water consumption	−0.210 (0.313)	107	0.271	0.625	73	29

Note: Values in parentheses are standard errors for the Firm + Year FE estimates. * denotes $p < 0.10$ for the Firm + Year FE baseline estimates. Wild-bootstrap p-values are reported separately in the Wild Bootstrap p column.

Table 12. Overseas exposure and foreign-ownership external-visibility heterogeneity.

Spec.	Outcome	Term	Estimate	SE	p	N
High foreign ownership	vc_inter	cust_x_high_foreign	0.024 **	0.011	0.026	1212
High foreign ownership	vc_depth	cust_x_high_foreign	0.026	0.018	0.15	1212
High foreign ownership, strict FE	vc_inter	cust_x_high_foreign	0.019 *	0.011	0.09	1212
High foreign ownership, strict FE	vc_depth	cust_x_high_foreign	0.022	0.017	0.181	1212
High overseas revenue	scope3	cust_x_high_overseas	0.006	0.045	0.896	1585
High overseas revenue	scope3_score	cust_x_high_overseas	0.053	0.142	0.708	1585
High overseas revenue	vc_inter	cust_x_high_overseas	0.004	0.061	0.945	1585
High overseas revenue	vc_depth	cust_x_high_overseas	−0.074	0.112	0.510	1585

* and ** denote $p < 0.10$ and $p < 0.05$.

Table 13 tests whether customer pressure is associated with environmental tax payments. The environmental-tax amount is not significantly related to customer pressure in either the baseline specification (estimate = −0.121, $p = 0.332$) or the strict fixed-effects specification (estimate = 0.009, $p = 0.969$). This result further indicates that the strongest evidence appears in value-chain disclosure, while environmental cost-bearing shows no comparable association.

Table 13. Environmental tax as a real-cost response.

Spec.	Outcome	Term	Estimate	SE	p	N
Environmental tax amount	env_tax_log	cust_press	−0.121	0.124	0.332	337
Environmental tax amount, strict FE	env_tax_log	cust_press	0.009	0.243	0.969	337

Table 14 provides a boundary test for Scope 3 disclosure. Firms that disclose value-chain interaction are more likely to disclose Scope 3 information (difference = 0.079, $p < 0.001$) and have higher Scope 3 disclosure scores (difference = 0.222, $p < 0.001$). However, within the subsample of firms that already disclose value-chain interaction, customer pressure has no significant additional association with any Scope 3 disclosure (estimate = −0.010, $p = 0.461$) or Scope 3 disclosure score (estimate = −0.065, $p = 0.139$). These results show that Scope 3 disclosure is nested within value-chain interaction disclosure, but customer pressure does not add explanatory power once firms already disclose value-chain interaction. The evidence supports a disclosure-channel boundary, not a substantive Scope 3 transmission pattern.

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Table 14. Scope 3 boundary test within value-chain accountability.

Spec.	Outcome	Term	Estimate	SE	t	*p*	N	Interpretation
Between VCI groups	scope3	vc_inter_diff	0.079	0.012	6.500	0.000	1701	Scope 3 disclosed only among VCI firms
Between VCI groups	scope3_score	vc_inter_diff	0.222	0.036	6.109	0.000	1701	Higher Scope 3 score among VCI firms
Within VCI disclosers	scope3	cust_press	−0.010	0.014	−0.738	0.461	495	No within-group customer-pressure effect
Within VCI disclosers	scope3_score	cust_press	−0.065	0.044	−1.480	0.139	495	No within-group customer-pressure effect

Note: VCI denotes value-chain interaction. The first two rows are descriptive group contrasts; SE/test reports the test type because these rows are not regression coefficients. The last two rows report fixed-effects coefficients on cust_press with firm-clustered standard errors within the VCI-discloser subsample.

This boundary has a clear theoretical reading. Value-chain interaction disclosure is largely qualitative: a supplier can describe upstream and downstream engagement in narrative terms at low cost and with little external verification. Quantified Scope 3 accountability is different in kind, because it requires primary activity data from partners, consistent estimation boundaries, and methodologies that can be checked [10–12,39]. Customer climate pressure moves the cheap, narrative margin, namely whether suppliers use value-chain language. It does not move the costly, verifiable margin, namely whether they report quantified Scope 3 emissions. It also adds no explanatory power for Scope 3 once value-chain language is already present (Table 14). Separating qualitative value-chain accountability from quantified emissions accountability therefore sharpens the contribution: the negative-to-null Scope 3 result is not a weak secondary finding but the boundary that defines what symbolic compliance can and cannot deliver.

The extended tests show that customer pressure is linked most clearly to value-chain accountability disclosure and foreign-ownership external-visibility heterogeneity. The evidence is weaker for Scope 3 quantification, reported environmental outcomes, and environmental tax.

5. Discussion

H2 receives qualified support. Customer climate pressure is associated with supplier value-chain carbon disclosure under the composite pressure measure in the full mapped-customer sample, and these associations are robust to a 5000-permutation randomization-inference placebo test (Appendix A Table A5, Panel A). The construct-overlap and same-sample diagnostics (Table 4 and Appendix A Table A5, Panel B) indicate a measurement and visibility boundary rather than a clean within-pressure decomposition: the depth-margin association is reproduced only where customer carbon-disclosure visibility is available, and on the smaller climate-only sample neither the composite nor the climate-only depth estimate is separately identified (0.016, $p = 0.735$; 0.012, $p = 0.778$). This pattern is itself consistent with disclosure-channel mimicry. H1 receives partial support. Customer pressure is positive for selected operational indicators, including green supply-chain strategy and green production, although these associations are less stable under stricter fixed effects and selection corrections. H3 receives partial support. The state-ownership interaction is positive for value-chain carbon-accountability disclosure, and other institutional and relational boundary checks are less consistent. Overall, the strongest and most stable finding is disclosure-channel visibility, not substantive supply-chain transformation.

The pattern is symbolic compliance in supply-chain carbon accountability. Customer disclosure visibility maps into supplier disclosure visibility. Broader customer climate-accountability signals are not robustly associated with supplier disclosure depth. No customer pressure measure is robustly associated with supplier emissions, resource use, environmental investment, or environmental tax under strict fixed effects and wild cluster bootstrap inference. Table 14 shows that Scope 3 disclosure is concentrated among firms that already disclose value-chain interaction, and customer pressure has no additional Scope 3 association inside that group. This is consistent with institutional isomorphism and decoupling [27,28,30]: suppliers adopt visible disclosure routines that resemble those of climate-accountable customers, while no comparable association is observed in underlying operational and environmental outcomes. The pattern echoes broader work on legitimacy-driven reporting [29,31]: when verifiable customer climate performance signals are noisy and disclosure is the most legible customer signal available, suppliers facing accountability pressure adopt the most legible response, which is disclosure that mirrors customer disclosure.

It is worth weighing this symbolic-compliance reading against alternative explanations. A first alternative is that the pattern is an artefact of limited coverage and measurement error: with customer pressure observed for about five percent of firm-years, real-outcome samples are small and noisily measured. A second is staged accountability, in which disclosure is a genuine first step and substantive change follows with a lag rather than never. A third is knowing-conservative disclosure, in which suppliers deliberately withhold quantified Scope 3 information until they have verifiable data. A fourth is reverse causality or matching, in which already-disclosing suppliers attract climate-accountable customers. The joint evidence fits symbolic compliance and decoupling more closely than these alternatives, although some alternatives are harder to exclude than others. We take differential measurement error seriously: the reported environmental outcomes are sparser and are observed on much smaller subsamples than the disclosure outcomes (Table 11), so a low-power or noise explanation for the real-outcome nulls cannot be excluded on the real-outcome arm alone. We therefore rest the discrimination on patterns that do not depend on the small-sample depth comparison: the value-chain disclosure associations are robust on the full sample under a 5000-permutation randomization-inference placebo test (p = 0.008 for disclosure depth and p = 0.002 for value-chain interaction (Appendix A Table A5, Panel A); no reported environmental outcome survives strict fixed effects with wild cluster bootstrap inference, and customer pressure adds nothing to Scope 3 within firms that already use value-chain language (Table 14). Staged accountability is harder to exclude, because a genuine first step need not produce substantive movement within our sample window; we can say only that we observe no such movement in-sample, and the lead-lag tests provide no evidence of delayed transmission for the outcomes we can track. Knowing-conservative disclosure would not produce convergence on the cheap value-chain margin while leaving the costly Scope 3 margin flat within the same firms (Table 14). Reverse causality is weakened by the placebo and lead-lag tests and by the selection corrections. On balance, the decoupling interpretation is the one most consistent with the full set of results, although we cannot rule the alternatives out entirely.

Why disclosure rather than substance? Three forces reinforce one another. Managerially, value-chain disclosure is the lowest-cost way to satisfy a legitimacy motive: it visibly signals responsiveness to customers, regulators, and investors without committing the firm to costly operational change [29]. Institutionally, coercive and mimetic pressures push suppliers to adopt the disclosure structures of climate-accountable customers, so that conformity is achieved through form rather than function [27,28]. External supervision of value-chain claims is weak. Quantified Scope 3 figures are hard to verify, and assurance is uneven. Selective disclosure is therefore difficult to detect and cheap to sustain [31]. Symbolic compliance is the predictable equilibrium when audiences reward visible conformity and cannot readily verify substance. This also clarifies what would change the equilibrium:

stronger external verification and assurance, together with procurement that conditions on audited data, would raise the cost of disclosure-only responses.

Appendix A Table A4 provides a descriptive pre/post-2021 comparison. The value-chain disclosure association is stronger in the pre-2021 period than in the post-2021 period, and the post-2021 estimates show no consistent strengthening. This pattern is not a causal policy test. The 2021 national carbon-market launch did not create a uniform value-chain disclosure mandate for listed firms, and the broader sustainability-reporting reforms in 2023 and 2024 fall outside a clean event window in our sample. Descriptively, the temporal pattern fits the symbolic-compliance reading: as climate-accountability expectations became more general after 2021, customer-specific disclosure pressure may have become less distinctive against broader institutional reporting pressure.

The foreign-ownership result is best read as external-visibility heterogeneity. Foreign ownership strengthens the customer-pressure association with value-chain interaction disclosure, but the effect does not extend consistently to disclosure depth or to real environmental outcomes. Cross-border ownership likely increases the salience of legitimacy audiences and makes disclosure alignment more valuable, without translating customer pressure into operational decarbonization. This is compatible with evidence that investors attend to carbon emissions and pollution risks [43,44], although our evidence concerns disclosure visibility rather than market pricing.

For managers, the findings indicate that customer pressure is observed in supplier disclosure routines and not in suppliers' real environmental outcomes in this sample. Customers can avoid disclosure-only mimicry by tying procurement to verified supplier emissions data, supplier-level audit routines, and Scope 3 collection protocols, and by linking these to contract terms. Suppliers should be aware that disclosure convergence with customers does not by itself signal operational decarbonization. Stakeholders interpreting supplier value-chain disclosure should distinguish disclosure depth from emissions performance.

For policymakers, the findings suggest that disclosure standardization on its own is unlikely to deliver supply-chain decarbonization. The 2024 Chinese stock-exchange sustainability guidelines, HKEX climate-disclosure requirements, and ISSB standards all increase the comparability and availability of sustainability information [20–24]. The present evidence is that comparability can produce disclosure convergence along the supply chain without corresponding changes in supplier emissions, resource use, environmental investment, or environmental tax. Mandatory sustainability-reporting research also shows that disclosure rules can shape information environments and market responses [35,45]. For customer pressure to support SDG 9 on industrial upgrading and SDG 13 on climate action [3,4], policies that standardize emissions data exchange, supplier reporting, and assurance need to be paired with mechanisms that translate verified data into procurement and contracting requirements.

The results also connect with recent supply-chain ESG research. Prior analytical and empirical studies examine how buyers and major customers can shape supplier responsibility, ESG activity, cost behavior, and ESG disclosure quality through supply-chain relationships [46–49]. The present study adds a carbon-accountability setting and shows that the transmission is concentrated in disclosure visibility. In this sample, suppliers appear to respond more clearly to what customers disclose than to broader customer climate-accountability signals.

Measurement issues also help to explain why disclosure-channel mimicry dominates in this setting. ESG ratings differ across providers [36,37], and rating noise can affect empirical estimates [50]. Future carbon metrics depend on emissions forecasts and valuation assumptions [38]. Scope 3 data are sensitive to data sharing, category coverage, provider

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modelling, and sector relevance [10–12,39]. When verifiable customer climate performance signals are noisy and disclosure is the most legible customer signal, suppliers facing accountability pressure adopt the most legible response. Adjacent work shows that higher green supply-chain management quality is associated with a greater likelihood of Scope 3 disclosure and a lower Scope 3 carbon footprint [51]. The present evidence identifies an upstream condition: disclosure mimicry can appear without the underlying supply-chain management quality being in place.

6. Conclusions

This study develops a supply-chain measure of downstream customer climate pressure and tests its association with supplier green supply-chain management, value-chain carbon accountability, Scope 3 disclosure, and reported environmental outcomes in Chinese listed firms. The association with value-chain carbon disclosure is robust on the full sample to a 5000-permutation randomization-inference placebo test, but it is reproduced only where customer carbon-disclosure visibility is available: on the smaller climate-only sample, neither the composite nor the climate-only depth estimate is separately identified. We interpret this pattern as a measurement and visibility boundary. It is consistent with disclosure-channel mimicry rather than substantive transmission. We find no robust evidence that any customer-pressure measure is associated with supplier emissions, resource use, environmental investment, or environmental tax under strict fixed effects and wild cluster bootstrap inference.

The pattern is symbolic compliance along the supply chain. Customer disclosure visibility maps onto supplier disclosure visibility. Substantive climate action does not travel through the same channel in this sample. For sustainable operations, the finding implies that traceable value-chain governance is necessary but not sufficient for emissions reductions, and reporting infrastructure on its own can produce disclosure convergence without corresponding decarbonization.

The study has two practical implications. For managers, supplier value-chain disclosure should not be read as evidence of supplier decarbonization. Procurement teams that want substantive change should pair disclosure templates with verified emissions data, audit routines, supplier-level Scope 3 collection, and contract terms that link verified performance to procurement decisions. For policymakers, the 2024 Chinese sustainability guidelines and IFRS S2-aligned climate rules will produce more comparable supply-chain disclosure. On their own, they may not be sufficient to produce supply-chain decarbonization. Mechanisms that translate verified data into procurement and assurance are needed for customer pressure to connect to emissions reductions.

Three evidence boundaries remain. The first is a scope condition rather than a peripheral caveat. Customer pressure coverage is narrow, at about five percent of firm-year observations, because disclosed top customer links must be matched to listed customer climate accountability signals. Covered firms also differ systematically from the full panel, with more state ownership and more concentrated supply chains (Table 6). The results therefore describe a specific population: suppliers with disclosed, mappable, and commercially salient listed customer links. They should not be read as representative of all customer and supplier relationships in China. Broader customer mapping through private customer matching, supplier registries, procurement records, or text-based customer identification is needed to improve external validity. Scope 3 disclosure remains sparse. Reported environmental outcomes are available for fewer firm-years. The fixed-effects models, placebo tests, selection corrections, and extended outcome tests strengthen the credibility of the association-based evidence and clarify the scope of interpretation. The construct-overlap test in Section 4.3 motivates further work in three directions. Primary or non-disclosure measures of customer climate performance, such as verified emissions data, regulatory enforcement records, or audited transition plans, are needed to test whether substantive customer climate action transmits to suppliers separately from disclosure visibility. Mandatory disclosure regimes that produce comparable supplier disclosure should not be read as evidence of supply chain decarbonization without parallel evidence on emissions and resource use. Whether value-chain disclosure represents an early stage of substantive accountability or a symbolic-compliance response in other institutional settings remains an open question for cross-country and cross-sector replication.

Future research can extend the design by reconstructing customer-identity-level panels, linking customers to policy shocks such as disclosure mandates or carbon-market coverage, and validating customer climate signals against licensed CDP or other external climate datasets. Such extensions would support stronger causal tests of supply-chain climate accountability.

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Abbreviations

The following abbreviations are used in this manuscript:

CDI	Carbon-disclosure index
CSMAR	China Stock Market and Accounting Research Database
GSC	Green supply chain
GHG	Greenhouse gas
Scope 3 emissions	Indirect greenhouse gas emissions across the value chain
CDP	Carbon-disclosure project
HKEX	Hong Kong Exchanges and Clearing Limited
IFRS	International Financial Reporting Standards
IMR	Inverse Mills ratio
IPW	Inverse probability weighting
ISSB	International Sustainability Standards Board
SOE	State-owned enterprise
TWFE	Two-way fixed effects
VCI	Value-chain interaction
AUC	Area under the receiver operating characteristic curve
COD	Chemical oxygen demand (a wastewater pollutant load)
CSR	Corporate social responsibility
ESG	Environmental, social, and governance
HHI	Herfindahl–Hirschman Index
SDG	Sustainable Development Goal

Appendix A

Table A1. IPW weight statistics.

Weight	Metric	Value
Raw stabilized IPW	n	1889
Raw stabilized IPW	min	0.141
Raw stabilized IPW	p01	0.172
Raw stabilized IPW	median	0.889
Raw stabilized IPW	mean	0.978
Raw stabilized IPW	p99	2.638
Raw stabilized IPW	max	4.827
Raw stabilized IPW	ESS	1399.137
Trimmed stabilized IPW	n	1889
Trimmed stabilized IPW	min	0.141
Trimmed stabilized IPW	p01	0.172
Trimmed stabilized IPW	median	0.889
Trimmed stabilized IPW	mean	0.972
Trimmed stabilized IPW	p99	2.635
Trimmed stabilized IPW	max	2.638
Trimmed stabilized IPW	ESS	1421.725

Note: Raw stabilized weights are trimmed at the selected-sample 99th percentile for the IPW robustness specification; ESS is the effective sample size.

Table A2. Variable definitions and extended-data coverage.

Variable	Variable Label	Data Module	Construction	N	Coverage (%)
cust_press	Customer climate pressure	Customer mapping + climate signals	Standardized exposure-weighted customer pressure	2265	5.23
cust_press_climate	Climate-only customer pressure	Customer mapping + climate indicators	Standardized from ambition/mgmt/performance items	1103	2.55
cust_disc_vc	Customer value-chain pressure	Customer mapping + CDI value-chain	Standardized pressure from customer VC disclosure	2254	5.20
cust_disc_idx	Customer CDI pressure	Customer mapping + CDI index	Standardized pressure from customer CDI	2254	5.20
cust_cov	Customer-mapping coverage share	Top-customer mapping	Share of customer exposure mapped to listed customer signals	2265	5.23
gsc_strategy	GSC management strategy	GSC_ManagementIndex	Indicator for disclosed green supply-chain management strategy	26,039	60.11
gsc_org	GSC management organization	GSC_ManagementIndex	Indicator for disclosed green supply-chain organization	26,039	60.11
gsc_supplier	Green supplier management	GSC_ManagementIndex	Indicator for implemented green supplier management	26,039	60.11
green_production	Green production	GSC_ManagementIndex	Indicator for green production practice disclosure	26,039	60.11
green_product	Green product	GSC_ManagementIndex	Indicator for green product practice disclosure	26,039	60.11
green_infodisc	Green information disclosure	GSC_ManagementIndex	Indicator for green information disclosure	26,039	60.11

Table A2. *Cont.*

Variable	Variable Label	Data Module	Construction	N	Coverage (%)
vc_depth	Value-chain carbon disclosure	CDI detail tables	Carbon-disclosure value-chain component	27,388	63.22
scope3	Any Scope 3 disclosure	CDI detail tables	Indicator equal to one for any Scope 3 disclosure	27,388	63.22
scope3_score	Scope 3 disclosure score	CDI detail tables	Scope 3 carbon-disclosure score	27,388	63.22
vc_inter	Value-chain interaction disclosure	CDI detail tables	Disclosure of upstream/downstream value-chain interaction	27,388	63.22
gsc_wordfreq_log	GSC text frequency	GSC word-frequency table	Log one plus green supply-chain word frequency	24,530	56.63
ep_invest_log	Environmental investment	EP investment table	Log one plus environmental protection investment	5489	12.67
Size	Firm size	Financial statements	Log total assets	27,618	63.75
Lev	Leverage	Financial statements	Total liabilities divided by total assets	36,253	83.69
ROA_c	Return on assets	Financial statements	Winsorized return on assets	28,974	66.88
Growth_c	Sales growth	Financial statements	Winsorized operating revenue growth	27,603	63.72
Cash_c	Cash holdings	Financial statements	Winsorized cash holdings scaled by assets	27,618	63.75
Top1	Top-1 ownership	Ownership structure table	Largest shareholder ownership percentage	28,056	64.76
SOE_binary	State ownership	Ownership/ property rights	Indicator equal to one for state-owned enterprises	43,320	100.00
Age	Firm age	Listing/firm profile	Years since establishment/listing	28,272	65.26
overseas_share	Overseas-revenue share	OFDI_OPERATEINCOME	Reported overseas-revenue share	15,431	35.62
high_overseas	High overseas exposure	OFDI_OPERATEINCOME	Indicator for high overseas-revenue exposure	15,431	35.62
analysts	Analyst following	AF_CFEATUREPROFILE	Number of analysts following the firm	17,686	40.83
foreign_share	Foreign ownership	ER_Structure	Foreign shareholding scaled by total shares	20,226	46.69
long_inst_prop	Long-term institutional ownership	INI_HolderSystematics	Long-horizon institutional ownership proportion	14,496	33.46
real_so2_log	SO_2 emissions	ENV_EmissionDetail	Log one plus reported SO_2 emissions	2178	5.03
real_nox_log	NO_x emissions	ENV_EmissionDetail	Log one plus reported NO_x emissions	2707	6.25
real_cod_log	COD discharge	ENV_EmissionDetail	Log one plus the reported annual COD discharge amount	3279	7.57
real_wastewater_log	Wastewater discharge	ENV_EmissionDetail	Log one plus reported wastewater discharge	2273	5.25
real_wastegas_log	Waste gas emissions	ENV_EmissionDetail	Log one plus reported waste gas emissions	865	2.00

Table A2. *Cont.*

Variable	Variable Label	Data Module	Construction	N	Coverage (%)
real_electricity_log	Electricity consumption	ENV_ResConsDetail	Log one plus reported electricity consumption	3469	8.01
real_water_log	Water consumption	ENV_ResConsDetail	Log one plus reported water consumption	3396	7.84
real_coal_log	Coal consumption	ENV_ResConsDetail	Log one plus reported coal consumption	622	1.44
ghg_log	GHG emissions	CNE_CEmissY	Log one plus reported greenhouse-gas emissions	2042	4.71
co2_emission_log	CO_2 emissions	CNE_CEmissY	Log one plus reported CO_2 emissions	303	0.70
ghg_red_log	GHG emissions reduction	CNE_CEmissReduceY	Log one plus reported greenhouse-gas emissions reductions	244	0.56
co2_red_log	CO_2 emissions reduction	CNE_CEmissReduceY	Log one plus reported CO_2 emissions reductions	1399	3.23
env_tax_log	Environmental tax amount	CNE_EnvirProtectTaxY	Log one plus reported environmental protection tax	5160	11.91
env_tax_burden	Environmental tax burden	CNE_EnvirProtectTaxY	Environmental protection tax scaled by revenue	5157	11.90

Note: Coverage percentages are calculated relative to the full firm-year analysis panel. Real-outcome variables have low coverage because they require both mappable listed-customer exposure and reported emissions, resource use, carbon-emissions, or tax data.

Table A3. Strict fixed-effects support for real-outcome tests.

Outcome	N Raw	Singletons	N Effective	Clusters	Absorbed df	Within R^2	Residual df
GHG emissions	117	101	16	8	7	1.000	5
CO_2 emissions reduction	83	67	16	6	3	1.000	5
SO_2 emissions	111	104	7	3	2	1.000	2
NO_x emissions	139	114	25	11	7	0.854	10
COD discharge	169	114	55	19	14	0.412	18
Wastewater discharge	123	99	24	10	8	1.000	8
Electricity consumption	201	132	69	27	27	0.416	26
Water consumption	183	110	73	29	25	0.681	28

Note: Statistics are from StataNow 19.5 models with firm and industry-year fixed effects. We treat outcomes with R-squared at or above 0.85 or residual degrees of freedom at or below 10 as having sparse support for strict fixed-effects inference.

Table A4. Baseline outcome subsamples around the 2021 national carbon-market launch.

Period	Outcome	Term	Estimate	SE	t	*p*	N	Clusters	Years
Pre-2021	gsc_strategy	cust_press	0.065	0.050	1.308	0.191	672	279	7
Pre-2021	green_production	cust_press	0.027	0.034	0.804	0.421	672	279	7
Pre-2021	scope3	cust_press	−0.000	0.000	−0.300	0.765	819	325	7
Pre-2021	scope3_score	cust_press	−0.000	0.000	−0.300	0.765	819	325	7
Pre-2021	vc_inter	cust_press	0.080	0.036	2.237	0.025	819	325	7
Pre-2021	vc_depth	cust_press	0.152	0.061	2.503	0.012	819	325	7
Pre-2021	ep_invest_log	cust_press					38	20	7
Pre-2021	gsc_wordfreq_log	cust_press	0.055	0.062	0.888	0.375	598	256	5

Table A4. *Cont.*

Period	Outcome	Term	Estimate	SE	t	*p*	N	Clusters	Years
Post-2021	gsc_strategy	cust_press	0.020	0.022	0.920	0.358	1100	534	4
Post-2021	green_production	cust_press	0.021	0.022	0.947	0.344	1100	534	4
Post-2021	scope3	cust_press	−0.027	0.019	−1.451	0.147	882	494	4
Post-2021	scope3_score	cust_press	−0.099	0.061	−1.624	0.104	882	494	4
Post-2021	vc_inter	cust_press	0.045	0.036	1.234	0.217	882	494	4
Post-2021	vc_depth	cust_press	0.068	0.060	1.141	0.254	882	494	4
Post-2021	ep_invest_log	cust_press	0.019	0.186	0.105	0.917	256	153	4
Post-2021	gsc_wordfreq_log	cust_press	−0.012	0.034	−0.342	0.733	1080	532	4

Note: This table reports descriptive pre/post-2021 comparisons. Post-2021 estimates vary across outcomes and show no consistent strengthening of the main value-chain disclosure result. The Pre-2021 ep_invest_log row is left blank because the subsample (N = 38, 20 clusters) is too small to support stable fixed-effects estimation. The 2021 national carbon-market launch is therefore used as institutional context in the main text.

Table A5. Same-sample construct-overlap and randomization-inference falsification tests.

Panel	Outcome	Specification	Estimate	SE	t-Stat	*p*-Value	N/Clusters
A. Randomization	Value-chain disclosure depth	Observed composite pressure	0.079	0.028	2.760	RI $p = 0.008$	1320/344
A. Randomization	Value-chain interaction	Observed composite pressure	0.054	0.017	3.113	RI $p = 0.002$	1320/344
B. Same-sample	Value-chain disclosure depth	Composite pressure on climate-only sample	0.016	0.047	0.339	0.735	616/175
B. Same-sample	Value-chain disclosure depth	Climate-only pressure	0.012	0.043	0.282	0.778	616/175
B. Same-sample	Value-chain interaction	Composite pressure on climate-only sample	0.044	0.028	1.579	0.116	616/175
B. Same-sample	Value-chain interaction	Climate-only pressure	0.041	0.025	1.600	0.111	616/175

Note: Panel A reports a year-stratified randomization-inference placebo test in which customer pressure is randomly reassigned within year 5000 times and the firm and year fixed-effects model is re-estimated in each draw; RI *p*-values are empirical two-sided *p*-values. Panel B reports same-sample construct-overlap diagnostics on the climate-only observable sample (N = 616). Standard errors are clustered by firm.

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